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Survey Paper on Computation Offloading UsingMobile Cloud Computing

Arshal D Mathew Department of ComputerEngineering
SVPCET
Nagpur, India Nirmal Abraham SunilDepartment of ComputerEngineering
SVPCET
Nagpur, India
Jessal George Department of ComputerEngineering
SVPCET
Nagpur, India

Aayush Bhojwani
Department of Computer EngineeringSVPCET
Nagpur, India
Prof. Komal Jaisinghani Department of Computer Engineering
SVPCET
Nagpur, India

Abstract— Mobile computational offloading is a promising method for enhancing the performance of mobile devices by shifting computationally demanding tasks to distant servers. Due to the increasing demand for mobile applications and the limitations of mobile devices in terms of processing power, battery life, and network connectivity, this technique has attracted a lot of attention recently. A thorough overview of mobile computational offloading is given in this survey paper, covering its fundamental ideas, architectures, and important technologies. The paper also highlights mobile computational offloading's potential applications and talks about its advantages and difficulties. Finally, a list of some challenges and future directions for this area of research.

Keywords- MCC; Computational Offloading; MEC; OffloadingArchitecture

I. INTRODUCTION

Mobile offloading is the process of offloading a part of the mobile application which may be a part of the code, a method, or a class to another processor outside the mobile device.[9] This in turn will reduce the load on the processor and help improve the system's efficiency. This method provides a cheap way for lower-end CPUs to perform more demanding tasks. The part of the application can be offloaded to another mobile device or a remote computer. The most practical place to offload is the cloud. Cloud infrastructure provides an excellent solution to offload as it provides processors of various choices and can be easily scaled up and down to meet the demands.

While offloading the tasks, the estimation of cost is very critical. As it is the main factor that decides whether to run the application locally or remotely. The estimation of the cost for offloading can be narrowed down to one main factor, the response time.

The response time in fact is dependent on the speed of the network and the payload the network has to carry in order to complete the execution of the task [12]. The framework implemented should efficiently choose whether to run locally or remotely by analyzing the trade-off between network speed and energy consumed. The mode of offloading, i.e., static or dynamic [13] should be decided considering these trade-offs. the response time can also be reduced by analyzing the behavior of the task and preparing the platform beforehand andmaking available the resources on the edge.

The number of smart wearable devices is increasing at a rapid pace in the market. But they come with a very limited CPU capacity and have a lower energy holding capacity. Wearable devices are always connected to a

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mobile device and hence if tasks that require a higher CPU can be offloaded. Thus, the applications of wearable devices can be increased to a great extent using MCC [8]

II. LITERATURE SURVEY

The efficiency of mobile devices can be increased through computation offloading. The paper discusses the combining of Mobile devices and the cloud, which is essentially Mobile Cloud Computing (MCC). Using MCC the processing ability and the storage capacity of mobile devices can be increased by using the cloud infrastructure. Thus, MCC provides an efficient solution to the problems that mobile devices inherit, viz. Limited energy storage, low CPU speed, and low storage capacity. Using MCC the tasks to be executed can be executed in the cloud and the result can be returned to the mobile device. This can be achieved using a Remote Procedure Call (RPC) or a Remote Method Invocation (RMI). The paper also discusses two possible offloading techniques they are static partitioning and dynamic partitioning. Static partitioning already places the method in the cloud whereas dynamic partitioning checks various parameters before partitioning the process.

[1] There are different models for offloading computational tasks. The major ones are MAUI [7], Clone Cloud System, [15] Cuckoo Design [14], and MACS Architecture. In the MAUI architecture, the profiler first checks whether the code has to be offloaded. The MAUI solver then uses the data collected by the profiler to decide whether to execute the code locally or to execute in the cloud.

In the Clone Cloud System dynamic code partitioning is performed. This system uses thread migration to enable offloading. The state of the thread of the process is copied to the cloud when the profiler decides to offload the process. Thissystem does not have resource constraints.

Cuckoo Design is an offloading methodology for Android devices. The jar file of the activity to be executed remotely is generated and a server with Java VM can be used to execute the jar file

MACS Architecture is similar to the Cuckoo Design but uses dynamic code partitioning. It provides offloading services on- demand. The application creates a query and sends it to the node manager. The node manager will invoke the activity and the results are then sent back to the application

[2] The number of mobile devices is expanding at a rapid pace. MCC can provide the users of mobile devices with the computing power of the cloud infrastructure. Its essential characteristics are on-demand services, Resource pooling, Rapid elasticity, and Measured service. The paper discusses the general architecture of MCC. In which the mobile device is connected to the cloud by a network connection either through GSM or an APN. The user can make requests to the cloud which are managed by controllers. Controllers process each request and the required service or resource is allocated to the user.

The paper also throws light on the challenges of MCC which is mainly the speed of the network used to connect to the cloud. The trade-off between saved energy and the response time should be carefully balanced to achieve a greater user experience

[3] Cloud Computing provides users with on-demand services and the users have to pay according to the time they have used the service. This provides the user with enormous amounts of computing power and storage space without actually owning the devices physically. Cloud services are provided by many vendors namely Amazon, Microsoft, Salesforce, etc.

The general components of the cloud are client computers, Distributed servers, and Data centers. The services provided by the cloud are SaaS, PaaS, and IaaS. The different types of cloud are public cloud, private cloud, and hybrid cloud. Cloud helps enterprises to save cost in computational tasks as the physical devices are owned and maintained by the vendor. As the vendor does this in scale computing becomes cheaper than actually owning the device.

[4] In this paper, the author compares MCC and MEC (Mobile Edge Computing) [11]. The author compares several independent studies on MCC and MEC to deduce the use casesof both technologies.

MEC can offer a low latency between the mobile device and the resource since the resource is placed on the edge. On the other hand, MCC comes with a latency that is from the APs and core network.

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To summarize the comparison, MCC can be used in a scenario where the computation requires a large number of resources and MEC can be used in a scenario where the device requires results with minimum latency and the task is less demanding inregards to CPU

[5] This paper proposes a system design for computational offloading by using a local network/cloud of mobile devices. This will eliminate the need for Internet connectivity. Hence it also solves the issue of variation in network bandwidth as the cloud is local.

The proposed system makes use of unused CPU in several devices to offload the task. All the offloading is performed dynamically. The system will analyze which devices can provide the resource and then proceeds to offload the task. Thepaper also provides proof of the efficiency of the local cloud over a mobile device.

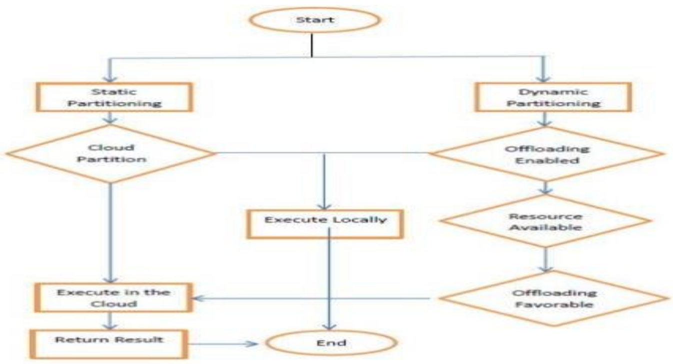

Figure I. Computation offloading workflow [1]

The above diagram shows the general working of computational offloading using the cloud. The process or method is partitioned for reducing load on the local CPU. Partitioning can either be static or dynamic.

TABLE I. COMPARISON TABLE

Author	***Year***	***Approach***	***Description***
K.K.Devadkar Dhananjay R.Kalbande and Avinash Sharma	2019	A distributed computing system for parallel applications	They proposed a distributed system that enables mobile devices to provide their CPU to locally connected devices
Dr.Jennifer S.Raj	2020	Classify mobile device using fuzzy K-nearest neighbor and offload using HMM and ACO	The author employs K nearest neighbor classifier and fuzzy rules to choose the best resource to offload, The author also proposes using HMM and ACO to predict the path of mobile devices

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Yunsik Son and Yangsun Lee [10]	2017	Fog computing to improve performance of VMs on mobile devices	The system transfers the selected method to fog based location. The local SVM sends the method to the server for execution. When the method is executed the context information is synchronized
Roberto Beraldi, Khalil Massri Abderrahmen Mtibaa And Hussein Alnuweiri [16]	2013	Using a pluggable middle-ware	Their architecture proposes a middleware, which takes into consideration the capabilities of the device. This Data is used to decide where the task should be offloaded.
Bowen Zhou, Amir Dastjerdi, Rodrigo N., Satish Srirama, and Rajkumar Buyya [17]	2015	Context-aware mCloud	To make the best offloading decision, the system considers an array of variables namely network availability, resource availability, cost, etc. The system uses the one-hop topology to guarantee consistency in case of failure.
P.Pratheepkumar, J. Josephine Sharmila and D. Arokiaraj [18]	2018	Generic offloading to heterogeneous devices.	The system automates offloading and facilitates offloading over disrupted networks. The offloading manager decides on the Resource by calculating the cost. The resource may be local, cloud, or cloudlet.

III. CHALLENGES AND FUTURE

A. Challenges

Mobile Cloud Computing provides a way to extend the life of a mobile device. While this technology has several advantages, such as enabling a mobile device to perform resource-intensive tasks and saving energy,

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it also has a number of drawbacks and trade-offs. Offloading algorithms used currently are not able to address all the major issues regarding MCC, which are discussed below:

- Network Latency: Offloading tasks from a mobile device to a server or cloud architecture necessitates a steady and dependable network connection. Network latency, on the other hand, might result in data transmission delays, resulting in reduced performance and user annoyance. As the device is mobile and hence the bandwidth might vary considerably while the user moves from one place to another, and the connection might even get cut off disrupting the transfer of data between the cloud resource and the device.
- Security and privacy: The offloading procedure necessitates the transfer of private user information to the cloud, which can be risky for both. Data breaches or other security problems may be caused by unauthorized access to user data while it is being sent or stored. The developers have to address possible attacks from different perspectives such as attacks on the cloud, attacks on the device, and breaches that may occur in the data transmission.
- Cost: Data transmission between mobile devices and cloud servers is required for computation offloading, which can result in significant data communication costs, particularly for mobile devices that depend on cellular connectivity. Along with this, there are also charges associated with the cloud resources used for computational offloading. Therefore, offloading the processes to the cloud should be economical enough for the user to be justified enough.
- Network Bandwidth: Offloading compute duties to the cloud can use a lot of network bandwidth, which can affect other apps that use the same network and network congestion. Bandwidth may also vary considerably as the user is mobile and sometimes may even cause a complete cut-off from the network. Therefore, the developers should construct handlers to tackle faults in data transfer.
- Application Compatibility: Due to the need for specific hardware resources, software libraries, or other factors, some programs may not be compatible with mobile computational offloading.
- Dependency on Cloud Infrastructure: Offloading mobile computation requires dependable cloud services and cloud infrastructure, which might result in a dependency on the cloud provider and vendor lock-in.

Performance Overhead: The offloading procedure itselfmay result in performance overhead, particularly for minor processing jobs or in cases of excessive networklatency, which would limit performance improvements.The algorithms decide whether to offload the process or not, or in some algorithms which component to offload might become an overhead whilecomputational offloading.

B. Future

The future of MCC is very promising and is expected to grow in the coming years. The increase in mobile devices, wearable devices, and IoT devices will provide a great opportunity for growth in MCC.

Using MCC to offload computational tasks can extend the capabilities of these devices without sacrificing the energystored in the device. Stored energy is very critical for wearableand IOT devices.

The future scope of Computational offloading is with the advent of quantum computers and expanding 5G networks. In order to scale down a quantum computer to the size of today's CPUs might take more time. This is where computational offloading can be used to make use of the enormous computing power of quantum computers to solve real-world problems.

IV. CONCLUSION

The paper analyzed the possibilities and challenges of using the Cloud for offloading computational tasks in a mobile device. The paper also analyzed different frameworks and algorithms and came to the conclusion that static offloading algorithms cannot provide the versatility of dynamic offloadingtechniques.

Different MCO strategies, such as cloud-based, edge-based, and hybrid offloading are compared in the

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paper, and the variables that affect how well MCO techniques work, such as network latency, energy use, and security concerns are examined.

It is clear that MCO can enhance user satisfaction and offer significant advantages for mobile devices with limited resources. Nevertheless, there are still a number of unresolved research issues that must be resolved, including designing effective MCO algorithms, guaranteeing the privacy and security of user data, and creating efficient resource allocation schemes.

In conclusion, MEC and MCC can be used for tasks with different demands of CPU in order to minimize the response time of the system.

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